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NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

NASA-05095 (March 2003)
NASA - KSC
SUPERSEDING NASA-05095
(September 1999)

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NATIONAL AERONAUTICS **NASA - KSC**
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SECTION 05095

WELDING OF CARBON STEEL (STRUCTURAL)
03/03

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NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This guide specification covers the requirements for the welding of structural carbon steel for non-conventional structures, inspection of welded joints, qualifications of welders, and welding machine operators.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: The following references should not be manually edited except to add new references. References not used in the text will automatically be deleted from this section of the project specification.

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The publications listed below form a part of this section to the extent referenced:

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(1993) Symbols for Welding, Brazing and Nondestructive Examination
AWS A5.1	(1981) Covered Carbon Steel Arc Welding Electrodes
AWS A5.17	(1980) Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
AWS D1.1	(1994) Structural Welding Code - Steel

JOHN F. KENNEDY SPACE CENTER (KSC)

KSC-SPEC-Z-0004	(Rev C; 1989) Welding, Structural, Carbon Steel, Stainless Steel, Low Alloy Steel, and Aluminum Alloys

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD 1949	(Rev A) Inspection, Magnetic Particle
MIL-STD 410	(Rev E; Notice 2) Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD 453	(Rev C; 1984) Inspection, Radiographic

1.2 WELD CRITERIA

Except as noted, all carbon steel welding shall be in accordance with AWS D1.1 and KSC-SPEC-Z-0004.

Classification: The following classifications shall establish levels of initial post-fabrication inspection. All levels of inspection shall be Class B.

Class A Inspection - Application to those welds where failure would be catastrophic in effect and welds which are highly stressed and characterized as a single point of failure with no redundancy for the redistribution of stress into another member. Groove welds shall be full penetration. Unless otherwise specified, Class A inspection requires radiographic inspection (see paragraph entitled, "Inspection")

Class B Inspection - Applicable to those welds where failure would reduce the overall efficiency of the system but loss of system or hazard to personnel would not be experienced. Unless otherwise specified, Class B inspection requires magnetic particle inspection for carbon steel and low alloy steel, and liquid penetrant inspection for stainless steels and aluminum alloys (see paragraph entitled, "Inspection")

Class C Inspection - Applicable to those welds where failure would not affect the efficiency of the system or create hazard to personnel and welds for connections of secondary members not subject to dynamic action and low stressed miscellaneous applications. Inspections for members and connections carrying personnel shall always be of a higher classification than Class C. Class C inspection requires visual inspection with suitable gages to assure proper size and good workmanship (see paragraph entitled, "Inspection")

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions

in Section 01330, "Submittals," and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

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The following shall be submitted in accordance with Section 01330, "Submittals," in sufficient detail to show full compliance with the specification:

SD-01 Preconstruction Submittals

Training data shall be submitted for welding inspectors in accordance with the paragraph entitled, "Certification of Welding Inspectors," of this section.

SD-02 Shop Drawings

Detail Drawings shall be submitted in accordance with the section entitled, "General" of this section.

SD-04 Samples

Representative samples of each type weld shall be submitted to the Contracting Officer prior to start of work.

SD-06 Test Reports

Test reports shall be submitted for the following items in accordance with AWS D1.1.

Welder Qualifications
Inspector Qualification Tests

SD-07 Certificates

Welding Procedures and Welder Qualifications shall be submitted in accordance with the paragraph entitled, "Qualifications of Welding Procedures and Welders," of this section.

Certificates shall be submitted for qualifications of welding procedures and welders in accordance with the paragraph entitled, "Certification of Welding Inspectors," of this section.

SD-09 Manufacturer's Field Reports

Inspection Reports of welds shall be submitted in accordance with the paragraph entitled, "Quality Provisions," of this section.

1.4 QUALIFICATIONS OF WELDING PROCEDURES AND WELDERS

Prior to any production welding, the Contractor shall demonstrate the satisfactory quality of representative welds by means of tests specified hereinafter under paragraph entitled, "Quality Provisions." Certificates of such qualification shall be current for welder qualifications and welding procedures and are subject to the Contracting Officer's approval. Certificates shall have the Government inspector's stamp affixed.

1.5 PROCEDURE AND PERFORMANCE QUALIFICATIONS

Contractor shall qualify welding procedures and welder performances.

Qualifications and certification shall be accomplished in accordance with the applicable portions of AWS D1.1 for carbon steel. Copies of certification shall be submitted to the Contracting Officer.

Retesting is not required for renewal of performance qualification if the welder has performed production welding meeting the requirements of this specification within the previous six months.

1.6 CERTIFICATION OF WELDING INSPECTORS

Welding inspectors shall be certified to meet the requirements of MIL-STD 410. Contractor may have an in-house level III certified inspector as a designated representative to certify other inspectors at levels I and II. As an option, he may use the services of a private laboratory, approved by the Contracting Officer, to provide a certified level III inspector to conduct qualification training and examination of the Contractor's personnel at level II. In such instances, the responsibility of certification shall be retained by the Contractor. Inspector Qualification Tests shall meet referenced standards within this and referenced sections.

If a private laboratory issued to provide qualification training and examination of the Contractor's inspectors, the Contractor shall have a least level II nondestructive testing (NDT) inspectors of the applicable testing method on his staff for performance of the required inspections. These inspectors shall be certified to perform inspections of the type required by the specifications.

Contractor may certify a level II inspector in magnetic particle or liquid penetrant and waive the required trainee or level I documented work experience time if the Contractor specifically ascertains that the employee is qualified to properly perform the required inspection and so states in his certification to the Contracting Officer. Once an inspector has been certified, no further training will be required for the life of the contract.

Contractor also has the option of using the services of a private laboratory, approved by the Contracting Officer, to provide the required NDT inspections.

Training data shall be submitted for welding inspectors. Data shall include description of training, training aids to be used, samples of training materials to be used, and schedules of training.

Certificates shall be submitted for qualifications of welding procedures and welders including the type of welding and positions each operator is qualified for, the code and procedure qualified under, date qualified, and the firm and individual certifying the qualification tests.

1.7 HANDLING AND STORAGE

All materials used in welding processes shall be stored so that no degradation will result during storage. Handling and storage methods shall be stated in the welding procedure.

PART 2 PRODUCTS

2.1 GENERAL

Base metal shall be as specified in AWS D1.1.

Welding rods, welding wire, and electrodes used in welding of carbon steel shall be capable of producing satisfactory welds when used by a certified welding operator with adequate welding apparatus and shall have a composition suitable for producing welds conforming to the requirements of KSC-SPEC-Z-0004.

Fluxes for carbon steel shall be of such composition that the carbon content of the resulting weld metal will be within the limits for the applicable base metal. Fluxes for submerged-arc welding shall be compatible with the filler metal and the base metal and shall be of such a composition that the qualities of the resultant weldment shall be equivalent to or better than those obtained by the electric-arc-coated electrode process.

Anti-spatter compounds, when used, shall be of a consistency and uniformity that degradation of the weldment will not result. Anti-spatter compounds shall also be easy to apply and remove.

Detail Drawings shall include the following:

Class A welds shall be transposed by the he contractor to detail drawings by designating "A" in the tail of the weld symbol. Detail drawings shall include notes specifying radiographic inspection for Class A welds. These notes shall be detailed enough to ascertain that a satisfactory radiographic inspection can be accomplished considering technique, fabrication sequence, and joint configuration for each Class A weld.

Class C Welds, when permitted, shall be identified on detail drawings by designating "C" in the tail of the weld symbol.

2.2 ELECTRODES FOR MANUAL SHIELDED METAL-ARC WELDING

Electrodes for manual shielded metal-arc welding of carbon steel shall meet the requirements of AWS D1.1. Electrodes shall be, covered mild-steel electrodes, E70 series conforming to AWS A5.1.

2.3 ELECTRODES AND FLUX FOR SUBMERGED-ARC WELDING

The bare electrodes and flux used in combination for submerged-arc welding of carbon steel shall meet the requirements of AWS D1.1 and shall be bare mild-steel electrodes and fluxes F70 series for submerged-arc welding conforming to AWS A5.17.

Shielded metal-arc electrodes having low-hydrogen coverings shall be [purchased in hermetically sealed containers] [dried for at least 2 hours between 450 and 500 degrees F 230 to 260 degrees C before they are used]. After opening, hermetically sealed electrodes shall be stored at all times in an oven, supplied by the Contractor, capable of maintaining a temperature of at least 250 degrees F120 degrees C.

The flux used for submerged-arc welding shall be dry and free of contamination from dirt, mill scale, or other foreign material. Flux used in welding shall not be reused.

PART 3 EXECUTION

3.1 JOINT PREPARATION

Interpretation of the weld symbols shall be made in accordance with AWS A2.4. Mismatch and misalignment of fit-up shall not exceed the allowable as shown in KSC-SPEC-Z-0004. Root opening of the joint shall be checked before tacking or depositing the first layer to ensure that it is correct. Oxide and protective coatings shall be removed. Surfaces to be welded shall be free of grease and other foreign matter. Any method of removal may be used which does not contaminate the surfaces. Edges to be fusion welded shall be essentially free of defects and finished to a surface roughness in accordance with AWS D1.1 for carbon steel.

Thermal or mechanical cutting may be used to cut carbon steel. Anti-spatter compound, when used, shall be applied to all surfaces adjacent to the joints where it is necessary to control spatter from welding.

3.2 PROTECTION OF EQUIPMENT AND ADJACENT SURFACES

Contractor shall protect equipment and adjacent surfaces during welding operations. Damages resulting from failure to provide protection shall be repaired to the satisfaction of the Contracting Officer, at no additional cost to the Government.

3.3 PROCEDURES

3.3.1 Preheating and Interpass Heating

Temperatures shall be measured by a surface pyrometer or other suitable temperature-indicating means, accurate within plus or minus 25 degrees F minus 4 degrees C. Heating an maintaining the proper temperature shall be accomplished, as applicable, by a furnace, by induction, by a gentle sootfree gas flame, by heat lamps, or by other suitable means capable of providing a reasonably uniform temperature throughout the part. When a gas flame is used for preheating, the area to be welded shall be brushed clean

of any soot before tacking or welding.

3.3.2 Tacking

Tack welds shall be used as required. Wherever possible, the tack welds shall be spaced symmetrically along or around the joint. Tack welds shall be of sufficient size and length to permit ease of subsequent welding, yet ensure holding of the parts in place without cracking of the tack weld. Chipping or grinding shall be done to fair both ends of the tack welds in with base metal. Tack welds which have cracked shall be removed.

3.3.3 Weld Beads

Weld beads shall be terminated so as to avoid critical areas of the weld. Assemblies shall be welded in the flat position whenever practical. The back step and skip methods of welding shall be used to lessen warpage when necessary. Tabs on which the arc can be struck or extinguished may be used wherever practical to minimize porosity at the beginning and end of the weld bead. When manual welding multipass welds in circumferential joints in tubular sections or depositing continuous-circular-butt or fillet-type welds, the first layer, whenever practical, should be deposited by welds in opposite quadrants. All machine welding or circumferential or circular type joints shall be accomplished utilizing a continuous single pass or multiple stringer technique. All groove welded joints which are to be welded from both sides and which require 100 percent penetration shall be back gouged, as necessary, to ensure complete penetration of the joint.

3.3.4 Techniques

Normally, two or three passes shall be deposited on the first side prior to the back gouging of the back side. Back gouging to sound metal may be done by chisel, grinder, or air carbon-arc process. Gouged areas shall be smoothed to fair in with adjacent metal. Starts and stops of each weld bead shall be chipped or ground as necessary to remove cracks and visible porosity in the weld metal before depositing the subsequent weld bead. Ground areas shall fair in smoothly with the adjacent material. Weld beads shall not terminate in inside corners or in other critical areas such as changes in welding direction or sudden changes in section thickness. Return welds shall be continuously full size around the corner for a length equal to twice the weld size. End returns shall be indicated on design and detail drawings. Corner welds may be a fillet weld, a butt weld, or a combination thereof depending of forming or drawing requirements. Unless otherwise specified, there shall be complete penetration to the inside of the joint permitted for contouring and blending when an inside fillet weld is not specified. The outside of the joint shall blend smoothly with the adjacent metal and unless otherwise specified, sufficient metal shall be added to provide a suitable fillet or reinforcement.

3.3.5 Postweld Heat Treatment

Stress relief or heat treatment of welded assemblies is optional unless specifically called for on the drawing.

3.4 IN-PROCESS REPAIR OF WELDMENTS

All defects of the weld metal shall be corrected at the discretion of the Contracting Officer. Welding procedures shall be the same as for the original weld.

If the weld is otherwise acceptable, excessive weld underfill, undercut, low weld beads, or crack-free craters may be corrected by laying an additional bead joining the original weld and the base metal and filling the depression. None of the original weld need be removed when penetration can be obtained to the bottom of the defect.

Defects such as cracks and surface imperfections shall be removed from the original weld by grinding or chipping or air gouge prior to rewelding. Areas with inadequate joint penetration may have the weld deposit partially removed prior to rewelding.

Unacceptable overlap and underbead defects shall be removed by dressing the weld deposit. Dressing of welds below the size indicated on the drawing shall not be permitted.

Government inspector will approve the proposed corrective action, as above, when acceptable, and will ensure that the area on the weldment to be corrected is marked for reinspection and that satisfactory repairs are made.

3.5 QUALITY PROVISIONS

3.5.1 Inspection Requirements

Contractor shall perform all inspection requirements as specified. Except as otherwise specified, the Contractor shall use his own or any other inspection facilities and services acceptable to the Government. Inspection and test records shall be kept complete and provided to the Contracting Officer or his designated representative. Contracting Officer, or his designated representative, reserves the right to perform (at Government expense and without any increase in contract price) any or all of the inspections set forth in this specification to ensure that the end item conforms to the prescribed requirements.

3.5.2 Inspection

Welds shall conform to AWS D1.1.

Radiographic inspection shall be performed by the Contractor on all Class A welds. In unusual cases where the Class A weld consists of, or is part of, multiple connections or corner or tee joints of varying thicknesses such that the joint configuration makes it impractical to obtain a satisfactory radiograph, a satisfactory alternate method of inspection, such as ultrasonic, magnetic particle, or dye penetrant inspection shall be proposed. When either magnetic particle or dye penetrant inspection is proposed as an alternate method of inspection for multiple pass Class A welds, each 1/2-inch 13 millimeter interval of thickness shall be so inspected. In all cases, the approval of the Contracting Officer shall be obtained.

Magnetic particle inspection shall be performed on 100 percent of all Class B complete penetration welds, for each 1/2-inch 13 millimeter interval of thickness. Class B partial penetration welds and fillet welds shall receive visual inspection with AWS gages for size and good workmanship.

Certain Class B welds, whose quality cannot be satisfactorily determined by the testing procedures set forth in "Inspection Requirements" and "Examination of Weldments," as determined by the Contracting Officer, shall be subject to radiographic inspection at Government expense but without increase in contract price.

3.5.3 Examination of Weldments

Joint design tolerance shall be inspected prior to welding to verify compliance with AWS D1.1. Weld joint fit shall be inspected for accurate alignment to ensure complete and sound penetration of the root pass. Inspector shall also inspect each root pass to ensure complete penetration and soundness.

Visual inspection of all welds shall be accomplished using AWS fillet and butt weld gages.

Magnetic particle inspection of Class B carbon steel weldments shall be performed in accordance with the requirements of MIL-STD 1949.

Radiographic inspection shall be conducted, when applicable, in accordance with AWS D1.1 and MIL-STD 453.

3.5.4 Acceptance Criteria

Defects shall not be in access of those specified in AWS D1.1 and KSC-SPEC-Z-0004. In case of doubt, the Contracting Officer may require coupons to be cut from base or weld material for destructive tests. When the material of weld does not meet the applicable specifications for strength and soundness, the Contractor shall be liable for the cost of the investigation of the defective area. When coupons are removed from any part of the structure, the members shall be repaired in a neat and workmanlike manner, with joints of proper type to develop the full strength of the members and joints cut, and with peening as necessary or as directed to relieve residual stress.

3.5.5 Inspection Record

An inspection record for each full penetration weld made in the field shall be prepared. A recommended format is available upon request to the Contracting Officer. Inspection records shall be made available to the Contracting Officer.

3.6 POSTWELD CLEANING

All welded assemblies shall be cleaned free of oxides, flux, scale, or other foreign matter prior to final inspection.

-- End of Section --